TOPEX GDR Correction / Jason Compatibility Product Users Guide

Forward to the October 2002 version

This document should be used with the User Notes for the revised gcpb product. The only changes to this document are to some references on the TMR drift which are now supersede by the new drift in the gcpb. As indicated in the gcpb notes the need for a further TMR correction for TOPEX yaw state has been identified but is not yet accounted for.

Forward to the Preliminary version, January 2002

The GDR Correction Product (GCP) has been under development for more than two years. While the analysis of the point target response changes of TOPEX altimeter side A is still not complete, it was deemed essential to provide compatibility with Jason models during the Jason cal/val phase. The GCP also corrects TOPEX data for changes in sigma0 calibration that have occurred over the past year.

This is the first release of both the product and this document. Improvements can certainly be made based on users' suggestions. Please send all product and document questions and suggestions to philip.s.callahan@jpl.nasa.gov . Questions specifically regarding PO-DAAC distribution of the GCP data should be sent to kelley.e.case@jpl.nasa.gov . Corrections and answers to questions of general interest will be posted on the PO-DAAC web site with the document.

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1. Introduction

1.1 Purpose and Scope of this Document

This document describes and provides usage notes for the TOPEX GDR Correction Product (GCP). The product may be used with either TOPEX Project GDRs (Refs. 1, 2) or PO-DAAC/AVISO Merged GDRs (Ref. 3). This product is also designed to provide corrections to TOPEX GDR data and compatibility with Jason (I)GDRs (Ref. 4) in geophysical models.

1.2 Purpose and Scope of the Product

Originally the GCP was intended to correct GDRs for Point Target Response (PTR) changes in the TOPEX "side A" altimeter (Alt-A) which operated from launch in August 1992 until February 1999. The most obvious of these changes was a more or less steady increase in the significant wave height (SWH) from approximately cycle 162 onward that reached about 0.4 m when the switch was made from Alt-A to Alt-B in February 1999 (cycle 235/236). Changes in PTR are also likely to affect the range measurement at the centimeter level. The amount of this change is still under investigation. Tide gauge calibration of

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the entire TOPEX data set suggest that the net change in sea surface height was less than or approximately 1 cm from the PTR change.

Changes to SWH and range will be determined by waveform retracking (usually simply called "retracking") using the method of Rodriguez (Ref. 7). Determining changes in range to much better than 1 cm and in SWH to better than 0.1 m became increasingly important as global change researchers attempted to determine sea level rise to better than 1 mm/yr globally and also to determine geographic patterns in the sea level change. The SWH is of interest not only as a geophysical variable but also because it is used in calculating the electromagnetic bias (EMB) that corrects the altimeter range. Furthermore, the EMB correction is different at the Ku and C band frequencies of the TOPEX altimeter, so that changes in EMB also cause changes in the estimate of the ionospheric correction.

The original premise of the GCP was that all data would be corrected by retracking to be consistent with data from very early in the mission (before approximately cycle 100) when there were no observed changes in the altimeter. Retracking of cycles 021 through 026 showed systematic differences between the GDR values of SWH and range at both K and C bands that were functions of hemisphere and orbit direction. In order to preserve as much of existing analysis as possible, it was decided to attempt to keep retracking from perturbing the values for early cycles simply because of the difference between retracking and the GDR. Thus, "quadrant adjustments" to K and C range and SWH depending on hemisphere and orbit direction (north ascending, north descending, south ascending, south descending, abbreviated as NA, ND, SA, SD) were introduced. Since Jason is being calibrated to Alt-B, the usefulness of these adjustments to Alt-A (or to Alt-B, for that matter) will have to be determined after Jason Cal/Val.

Finding a reliable way of estimating the PTR proved to be much more difficult than expected, so the GCP was still not released as Jason launch approached. It was then decided to add additional fields to the product to make the TOPEX data compatible with the Jason data. As indicated below, these "Jason compatibility" fields are named with a prefix of "jas_". Furthermore, in order to provide data quickly for global comparisons during Jason Cal/Val, the GCP software was modified to produce GCPs using just TOPEX (I)GDRs.

1.3 Product Availability

GCPs for all TOPEX Alt-B cycles available at the beginning of January 2002 were produced *en masse* from the GDRs with no retracking. GCPs will be made from TOPEX IGDRs on a daily basis throughout the Jason Cal/Val period. The GCPs will be regenerated for each cycle when the TOPEX GDRs become available. This will allow for correcting the inverse barometer effect and for any sigma0 changes that are discerned during the month delay of the GDRs.

During the Jason Verification phase, GCPs are available to the Jason Science Working Team from the following password protected ftp site:

ftp podaac.jpl.nasa.gov, directory "gcp"

with the previously distributed user_name and password. Questions regarding PO-DAAC distribution of the GCP data should be sent to kelley.e.case@jpl.nasa.gov .

1.4 Conventions

In general, references to "GDR" will apply to both TOPEX Project GDRs and Merged GDRs (MGDR) from PO-DAAC and AVISO. However, the reference is actually to TOPEX GDRs unless MGDR is mentioned specifically.

Corrections to GDR quantities (except gcp_inv_bar which is a geophysical effect, gcp_Geo_Bad2 that contains various flag bits) have been given names beginning with gcp_. The names are usually identical to the TOPEX GDR name.

It is critical to read the sections on GDR Corrections and Jason compatibility to understand which fields give full values and which give deltas/corrections and also the sense/sign of the value. In general, corrections give deltas and geophysical effects (e.g., Jason compatibility) give full values.

The notation K/C indicates that the quantity is given for both K (Ku band, 13.6 GHz is referred to as K throughout) and C (5.3 GHz) bands.

The TOPEX conventions/definitions for length, range, and height have been used consistently throughout. All lengths (other than SWH) are given in integer millimeters. The product description should be checked carefully to determine whether one byte quantities are signed or unsigned.

The TOPEX convention for flagging has been used as consistently as possible. Flags should be checked to determine whether values of zero, a field maximum or minimum are true values or indicate that a value was not computed or exceeded the allowed range. Field max/min values that are not flagged indicate the sense in which the value exceeded the field size, i.e., an unflagged value of –127 indicates that a quantity stored as one byte was less than or equal to –127, while 128 indicates that it was greater than or equal to 128. For Jason values, some fields carry a flag value such as 9999 to be consistent with the Jason algorithm and product (see item descriptions).

1.5 References

The TOPEX GDR SIS (Ref. 1) and Users Handbook (Ref. 2) have been updated with a number of changes since their release. A compilation of the GDR updates is available by email from philip.s.callahan@jpl.nasa.gov .

1. TOPEX GDR Data SIS (with updates), March 1993, JPL D-8590 Rev C.

2. TOPEX GDR Users Handbook Draft-2, October 1993 (with updates), JPL D-8944 Rev A.

3. PO-DAAC Merged GDR Version B Users Guide, Version 2.0, July 1997, JPL D-11007.

4. N. Picot, K. Case, S. Desai and P. Vincent, "AVISO and PODAAC User Handbook. IGDR and GDR Jason Products", SMM-MU-M5-OP-13184-CN (AVISO), JPL D-21352 (PODAAC), 2001.

5. G.S. Hayne, D.W. Hancock III, http://topex.wff.nasa.gov/docs/:
   “TOPEX sigma0 calibration table history for all side-A data”, July 1999.
   “TOPEX side-B sigma0 calibration table adjustments”, September 2001.

6. G.S. Hayne, “TOPEX altimeter range stability estimate update”, http://topex.wff.nasa.gov/docs/RangeStabUpdate.html, October 2001.

7. E. Rodriguez and J. Martin, “Assessment of the TOPEX altimeter performance using waveform retracking”, J. Geophys. Res., *99 C12*, 24,957, 1994.

8A: Keihm S., V. Zlotnicki and C. Ruff. TOPEX Microwave Radiometer Performance Evaluation, 1992-1998, IEEE Trans. Geosci. Remote Sens., *38*, 1379-1386. 2000.

8B: Ruf, C.S.: Characterization and Correction of a Drift in Calibration of the TOPEX Microwave Radiometer, IEEE Trans. Geosci. Remote Sens, *40*, 509, 2002

9. Lemoine, F. G., et al., The development of the joint NASA GSFC and NIMA geopotential model EGM96, NASA/TP-1998-206861, 575 pp, July 1998.

10. Ray, R. D., “A global ocean tide model from TOPEX/POSEIDON altimetry/GOT99.2”, NASA TM-1999-209478, pp 58, Goddard Space Flight Center, NASA, Greenbelt, MD, 1999. (Jason tide 1)

11. Lefevre, F., F. Lyard, C. Le Provost, and E. J. O. Schrama, “FES99: a tide finite element solution assimilating tide gauge and altimetric information”, submitted J. Atm. Oceano. Tech., 2000. (Jason tide 2)

12. J. Gourrion, D. Vandemark, S. Bailey, B. Chapron, “Satellite altimeter models for surface wind speed developed using ocean satellite crossovers”, Report No. : IFREMER-DROOS-2000-02, 2000.

13. P. Gaspar, S. Labroue, F. Ogor, G. Lafitte, L. Marcahl, M. Rafanel, “Improving non-parametric estimates of the sea state bias in radar altimeter measurements of sea level”, submitted J. Ocean Tech., 2001.

2. Product Description

The product layout is given in the attached spreadsheet.

2.1 Header

The header consists of **86** records in “parameter = value” ASCII text format. Each line is terminated with a semi-colon, carriage return, line feed. Header records will always be sized to be twice the length of the data records (currently 52 bytes). Thus, if the data format is changed, the header size will change as well. Items are padded after the value with blanks to give the required length.

The parameter part of each record consists of an item name or description. The value part gives the information pertaining to that item. Values may be either character or numeric.

The first 42 header records are a copy of the information from the TOPEX GDR header. The additional items give information about aspects of the production of the GCP.

2.1.1 GDR Correction Product Information

The first three items provide the time the file was made and identification of the software used. When the Software Interface Specification is finalized, the SIS version will be included.

The fourth item gives the number of GDR records for which a retracking record is not available (retracking failed to converge). For GCPs made from (I)GDRs this value will be the total number of records. Records for which there is not a retrack record will have gcp_flag bit 0 set to 1. Other items that directly give retrack values will be 0 (gcp_range_K/C, gcp_SWH_K/C, gcp_accCorr, rdr_pts_avg), but most fields may have a non-zero value, particularly if there is a change in sigma0_K.

2.1.2 Sigma0 Calibration

The sigma0 correction information is from the WFF web site Ref. 5 (Alt-A,B). Both the full correction to the sigma0 calculated in the TOPEX GDR algorithm (i.e., the value that should have been used as the sigma0 calibration value during GDR processing) and the delta from the value actually used in the TOPEX GDR as distributed by PO-DAAC is given. The key point is that the values in each data record, gcp_sigma0_K/C, are the fully corrected sigma0.

2.1.3 Instrument Range Calibration

The altimeter internal instrument range correction (not temperature adjusted) from the WFF web site (Ref. 6) is given. This correction is **not** applied to the GCP data (nor in the TOPEX GDR), but it is applied in the MGDR.

2.1.4 Retracking Information

Information about the waveform retracking that produced the corrections is given. Of course, this information will be “placeholder” if the GCP was made from only (I)GDR. Also, currently the retrack program does not provide this information, so it is always “placeholder”. Work is underway to revise the retrack software to provide this information.

2.1.5 TMR Tb18 Loss Correction

The TMR calibration of Zlotnicki (Ref. 8) assumes that the change in Tb18 is caused by a change in loss within the TMR. The change in loss is effectively constant for a pass and is given in the header. The fixed change in loss gives a change in brightness temperature that varies with the background, i.e., with Tb18; therefore the correction to Tb18 and hence to the wet tropospheric quantities are computer for each GDR point.

2.1.6 Quadrant Adjustments

GCP processing allows for the possibility of adjustments that depend on hemisphere and orbit direction as discussed in Section 1.2. The value of each adjustment is recorded in a header element.

2.1.7 Jason Information

global_avg_press gives the global average pressure interpolated to the equator crossing time from values determined at 6 hour intervals from ECMWF fields. The file containing the average values is obtained from CNES/CLS at ftp://ftp.cls.fr/pub/oceano/calval/pression/ . If the pass time is beyond the end of the currently available file, a value is obtained from a formula with an annual sinusoidal variation fit to 3 years of data. If the model is used, the value in **global_avg_press** will be **negative** as a flag.

Other fields give identification information about Jason constants and fields. It is likely that the GCPs will have to be entirely regenerated after Jason Cal/Val in order to maintain full compatibility between TOPEX and Jason.

2.2 TOPEX GDR Corrections

Except for the sigma0 values, all correction values are given as changes from the GDR quantities (note below that this is different than geophysical effects, mainly for Jason described below). The corrections follow the TOPEX convention in that they are to be added to the GDR quantity to get the corrected/improved value, i.e.,

Corrected_GDR_quantity = GDR_quantity + gcp_correction .

Each record is tagged with the **Time_Past_Epoch** from the GDR. While there should always be an exact record by record match of the GCP with the GDR, the time tags can be used to check for discrepancies.

2.2.1 GCP Sea Surface Height (gcp_SeaSurfHght)

gcp_SeaSurfHght is the total correction to the TOPEX GDR sea surface height (Sea_Surf_Hght) from all sources. The possible sources include
(1) retracking corrections to range (gcp_Alt_Range (K band)) including the acceleration correction and quadrant adjustment;
(2) change to K band EM Bias from retracking changes in SWH or changes in sigma0_K;
(3) change to the ionospheric range correction from retracking range changes and changes to EMB at either K or C band;
(4) TMR drift correction (gcp_Wet_Tropo_Rad) to the wet tropospheric correction.
As indicated in Section 2.1, neither gcp_Alt_range nor gcp_SeaSurfHght contain the WFF altimeter range correction. This quantity will generally be non-zero even when GCPs are made without retracking, particularly if there is a change in sigma0.

Analysis shows that this correction is noisier than expected. Much of the apparent noise in **gcp_SeaSurfHght**, **gcp_Alt_Range,** and **gcp_Iono** is caused by the very noisy acceleration correction (**gcp_accCorr**). It is recommended that users develop procedures to smooth these quantities along track to reduce the apparent noise to levels more consistent with intrinsic altimeter performance (See Section 3.3).

2.2.2 GCP Altimeter Range (gcp_Alt_Range)

gcp_Alt_Range is the total correction to the range on the Merged GDR. If one is using MGDRs, one must make the sea surface height (SSH) according to the MGDR formula and add the GCP correction for each quantity included. gcp_Alt_Range includes the acceleration correction (gcp_accel) that is needed with retracking. If gcp_flag bit 0 indicates that retracking is not used, this quantity will be 0.

2.2.3 SWH Corrections (gcp_SWH_K/C)

gcp_SWH_K/C is the correction in 0.1 m to the respective significant waveheight. If retracking is not used, these quantities will be 0.

2.2.4 Corrected Sigma0s

The sigma0 values are given as full values because there have been several versions of sigma0 corrections. The change from the GDR calibration correction and the total calibration correction are given in the header. These values are from the WFF tables available on-line at Reference 5. While the Alt-A corrections are unlikely to change, the Alt-B corrections may be updated as the sigma0 variations become more clear with time.

2.2.5 EM Bias Corrections (gcp_EMB_K/C, gcp_EMB_K_G4)

The EM Bias corrections are the result of using the corrected SWH_K and sigma0_K in the TOPEX and Gaspar four parameter EMB models. Because SWH is only recorded to 0.1 m on the GDR, SWH is obtained by back calculation from the GDR EMB_K. This may cause some rounding effects for gcp_EMB_C or gcp_EMB_K_G4, but this should not be a problem for gcp_EMB_K as it is found from the ratio of new and old wind speed expressions.

2.2.6 Ionosphere Correction (gcp_Iono)

gcp_Iono is the correction to the GDR ionosphere value or range correction from all sources. Change to the ionospheric range correction can come from retracking range changes and changes to EMB at either K or C band.

2.2.7 Off Nadir (Attitude) Correction (gcp_OffNadir)

gcp_OffNadir is the “correction” to the off nadir angle found in retracking. Correction is used advisedly as analysis shows that the values from retracking are systematically different than the GDR values in ways that are not completely consistent with the understanding of how the TOPEX satellite is pointed. Thus, this difference between the retrack and GDR off nadir angles is likely related to specific treatment of the waveform in retracking. The retrack off nadir angles show an average near 0.05 deg and very little variation. The GDR off nadir angles show a major peak at 0 deg believed to be consistent with the statistics of the quantity used to calculate them. Unfortunately, the GDR off nadir angles do show significant hemisphere and ascending/descending effects indicating that they are corrupted by the leakages in the TOPEX waveform. It is recommended that pending further analysis the original GDR off nadir angles be used.

2.2.8 Instrument Range Corrections (gcp_rangeK/C)

These are the corrections from retracking to the respective ranges including the appropriate quadrant correction, but not including the acceleration correction. If gcp_flag bit 0 indicates that retrack data were not used, these values will be 0. The values have been smoothed over **rdr_pts_avg** of 10 (5) possible K (C) band waveforms in a frame. The retrack smoothing algorithm is the same as that used in TOPEX (I)GDR processing – a least absolute deviations fit with extreme outliers discarded.

2.2.9 Flags (Geo_Bad, gcp_SSH_Bad, gcp_Alt_Bad1, gcp_Flag)

Geo_Bad is a copy of Geo_Bad from the GDR.

gcp_SSH_Bad is SSH_Bad from the GDR with bits for the 10/frame points modified to indicate if the retrack point was used in the smoothing. Bit 13 (spare in the GDR) indicates whether the gcp_SSH_Bad is different than SSH_Bad on the GDR.

gcp_Alt_Bad1 is the same as GDR Alt_Bad1 except that bit 0 will be modified to indicate the smoothing of the retrack data which could be different than the GDR.

gcp_Flag is described near the bottom of the product description listing. The key bit is bit 0 that indicates whether a good retrack record was found for this record. Of course, in the case of GCPs made only from (I)GDRs this bit will always be set.

2.2.10 Acceleration Correction (gcp_accCorr)

An acceleration correction is included in (I)GDR processing to account for the altimeter tracker "lag" in the presence of a range acceleration (The tracker will follow a constant range rate accurately.). The acceleration value is not included on the GDR, so it is estimated as a final step in retrack processing. If gcp_flag bit 0 indicates that retracking is not used, this quantity will be 0. This correction is included in **gcp_SeaSurfHght** and **gcp_Alt_Range** so that they can be used directly to correct the indicated quantities.

Analysis shows that this correction is quite noisy, and this noise causes much of the apparent noise in **gcp_SeaSurfHght** and **gcp_Alt_Range** . It is recommended that users develop procedures to smooth these quantities along track to reduce the apparent noise to levels more consistent with intrinsic altimeter performance.

2.2.11 Number of Retrack Points Smoothed (rdr_pts_avg)

rdr_pts_avg gives the number of 10/frame K band retrack points in a frame that were used in final smoothed value for the frame. The smoothing algorithm is the same as that used in (I)GDR processing.

2.2.12 TMR Drift, Wet Troposphere (gcp_Tb18, gcp_Wet_Tropo_Rad)

The TMR correction is due to a drift described in detail in Keihm et al (2000, Ref 8A). The specific correction implemented in the GCP is due to Ruff (2002, Ref 8B). The latter found that the 18 GHz brightness temperature drifted approximately linearly from the beginning of the mission until the end of 1996. The change in the 18 GHz brightness temperature (Tb18) is given in gcp_Tb18. The corrected value of Tb18 along with the original values of Tb21 and Tb37 are used in the wet tropospheric algorithms to redetermine the wet delay and the liquid amount for the rain flag. The change in wet tropospheric delay is given in gcp_Wet_Tropo_Rad. The TOPEX rain flag based on the revised calculation of liquid is in gcp_Geo_Bad2 bit 0, while bit 1 indicates whether this is a change from the original rain flag. The Jason rain flag (gcp_Geo_Bad2 bit 2) uses the revised liquid amount along with the K-C sigma0 difference.

The change in Tb_18 is thought to be due to a change in the loss of switches in the TMR front end (Ruf and Zlotnicki). The change in loss (assumed to be constant over one pass) is recorded in the header in "TMR Tb18 loss correction".

2.3 Jason Compatibility Fields

The Jason compatibility fields are identified by a jas_ at the beginning of the variable name. These items are computed using Jason Project algorithms with very minor modifications indicated in Section 3. Much more information about the Jason fields can be found in the Jason GDR Handbook (Ref. 4).

Geophysical effects fields have the sign and "direction" of the effect. Thus, if jas_tide1 is positive, it indicates that the tidal effect is to raise the sea surface. Similarly, if the inverse barometer (gcp_Invert_Barom) is positive, it indicates that the pressure at that point was less than the global average for that time so the instantaneous inverse barometer effect causes the sea surface to be higher than it would be for the average pressure.

2.3.1 GCP_Geo_Bad2

gcp_Geo_Bad2 contains flags related to Jason compatibility items.

Bit 0 gives the TOPEX rain flag calculated with the revised Tb18 liquid amount.
Bit 1 indicates whether bit 0 is different than the original TOPEX rain flag.

Bit 2 is the rain flag calculated with the Jason algorithm using the corrected liquid amount and corrected TOPEX K and C band sigma0s.

Bit 3 is the Jason ice flag (to be updated during Jason Cal/Val).

Bit 4 is the flag for jas_tide1 (GOT99), 0 = OK, 1 = not available.

Bits 6-7 give a quality indication for jas_tide2 (FES99) based on the number of points available for interpolation, 0 = 4 pts used, 3(11) = out of gridded area (see product description). This is not identical to the Jason flagging convention but is similar to that used for the FES tide in TOPEX.

2.3.2 Inverted Barometer (gcp_Invert_Barom)

The instantaneous inverse barometer correction involves the difference between the local barometric pressure and the contemporaneous global average. The global average is determined by time interpolation at the equator crossing time in global average pressures from CNES (ftp://ftp.cls.fr/pub/oceano/calval/pression/moy_globale_spatiale.txt) at 6 hour intervals. The interpolated global average value is recorded in header element **global_avg_press**. The local pressure is determined from the dry tropospheric correction as described in Ref. 3 Sec 4.8. The inversion for the local pressure results in a quantization of the inverse barometer correction to 4-5 mm.

2.3.3 Jason Land Flag (jas_Land_Flag)

The Jason land flag algorithm has been implemented to provide flag values in the same format as Jason at the TOPEX GDR locations. The values 0-3 are given on the product description.

2.3.4 Jason Mean Sea Surface (jas_Mean_Sea_Surf)

The Jason mean surface algorithm and data file, GSFC00.1,are used to provide the mean sea surface height at the TOPEX GDR locations. The difference between the fully corrected sea surface height and the mean sea surface is often referred to as “sea surface (height) anomaly”.

2.3.5 Jason Geoid (jas_Geoid)

The Jason geoid algorithm and data file, EGM96 (mean tide) Ref. 9, are used to provide the geoid height at the TOPEX GDR locations.

From email of Nikolaos Pavlis: The geoid undulations are given with respect to an ideal geocentric mean Earth ellipsoid, whose semi-major axis remains undefined (i.e., there is no zero-degree term in the spherical harmonic series of these geoid undulations). The flattening of this reference ellipsoid is f=1/298.257 so that the values are consistent with constants adopted for TOPEX/Poseidon.

2.3.6 Jason Tides (jas_Tide1, jas_Tide2, jas_Load_Tide)

Flags for the Jason tides are in gcp_Geo_Bad2. Modifications to the Jason tide algorithms are discussed in Section 3.1 .

Both Jason tides, like TOPEX tides, are the elastic ocean tide, the tidal effect observed by an altimeter, given schematically by
Elastic_ocean_tide = tide_model +long_period_equilibrium_tide + loading_tide .

There are two tide models as described below. The long period equilibrium tide is from the 123 “line” (frequency) model created for TOPEX. As explained in Section 3.1 this is different than the models typically obtained over the Internet. The loading tide is computed explicitly for the FES99 model (jas_Tide2) and is given in **jas_Load_Tide**.

jas_Tide1 (Ref. 10) is GOT99.2 with the long period tides described above.

jas_Tide2 (Ref. 11) is FES99. It includes its own loading tide effect.

jas_Load_Tide is from FES99. Note that the loading tide should be defined everywhere, but it is given only where the FES ocean tide is valid.

2.3.7 Jason Wind Speed (jas_Wind_Sp)

The wind speed from the Jason wind speed algorithm (Ref. 12) with modifications described in Section 3.2 is given in meters per second.

2.3.8 Jason Combined Electromagnetic Bias (jas_Comp_EMB)

The EMB bias for the K and C range combined to eliminate the ionospheric range delay is given for the Jason wind speed and the gcp-corrected TOPEX SWH. Some features of the Jason EMB model (Ref. 13), in particular flag values, are discussed in Section 3.3.

The combined EMB can be computed from the K and C band corrections by
EMB_combined = (1 + factor) * EMB_K - factor * EMB_C
where factor is (freq_C / freq_K)^2 / (1 - (freq_C / freq_K)^2) = 0.179 for TOPEX frequencies.

An initial comparison of TOPEX and Jason EMB models shows that the Jason values are larger. Adjustment(s) will need to be made during Jason cal/val to harmonize the results for EMB and ionosphere as well as sea surface height.

3. Algorithm and Usage Notes

3.1 Tides

Two important changes were made to the tide algorithms that one normally obtains over the Internet:
(1) the long period equilibrium model was replaced with the TOPEX model;
(2) the nodal update in GOT99 is done for every point rather than at a fixed number of days.

The tide models obtained from the recommended web sites contained a l long period equilibrium model with only 15 tidal lines while the TOPEX model has 123 lines. While the differences are quite small, the model was replaced for consistency with TOPEX and Jason.

It was pointed out by Shailen Desai during testing of the GCP that the GOT99 model had a test based on the time of the current point for updating the nodal correction in model. Shortening the time interval for updating was tried, but it was found that there were still 1 mm differences from updating every point. In order to make the GCP as compatible with Jason as possible, the time test was removed so that the nodal correction is now updated for each point with the call to GOT99.

3.2 Jason Wind Speed

It was found that the algorithm given in Ref. 12 that is being used for the Jason wind speed returned negative wind speeds for relatively large sigma0s (>~20 dB) and low SWH (<~1.0 m). While this may be a statistically reasonable result, it is not physical and also caused problems in the Jason EMB bias algorithm. It was decided to modify the algorithm slightly to give more physical results.

First, wind speeds less than 0 were passed to the Jason EMB algorithm as 0. That algorithm returns sensible values of EMB for wind speed = 0 for low SWH and flag values (see Jason EMB discussion) for high SWH. For algorithm wind speeds less than 0 the wind speed output jas_Wind_Sp is set to 255 (max of 1B unsigned integer). Second, since the Jason EMB algorithm does not have entries for wind speeds greater than 20.8 m/s and the TOPEX wind speed algorithm attained a maximum value of 21.73 m/s for adjusted sigma0 <= 7.0, it was decided to report wind speeds >= 25.0 m/s as 250 (i.e., 25.0 m/s). Thus, jas_Wind_Sp values of 251-254 are reserved for possible use as flags.

3.3 Jason EM Bias

The Jason EM Bias model is described in Ref. 13. It is based on improved non-parametric fits to TOPEX crossover data. The model is table driven with intervals of 0.25 m/s in wind speed and 0.25 m in SWH. The authors decided not to insert table values outside of the area in which significant data exist. Therefore, valid values are available in roughly an oval with no values at high SWH for low wind speed and no values for low SWH at high wind speed. There are at least some table entries for wind speeds from 0 to 20.8 m/s and for SWH from 0 to 9.75 m. Wind speed/SWH pairs for which sufficient data did not exist to do a fit return a flag value (9999 from the algorithm) which is reported in the GCP as the field maximum.

3.4 Along-Track Smoothing

Analysis shows that the key corrections (**gcp_SeaSurfHght**, **gcp_Alt_Range, gcp_Iono**) are noisier than expected. Much of the apparent noise in these quantities is caused by the very noisy acceleration correction (**gcp_accCorr**). It is recommended that users develop procedures to smooth these quantities along track to reduce the apparent noise to levels more consistent with intrinsic altimeter performance. Very cursory analysis indicates that along-track smoothing over approximately 10 points gives noise values more consistent with GDR variations. Noise effects are discussed in Ref. 7. Further analysis is needed to develop the best techniques for smoothing.